521282S Biosignal processing II (Lab exercises, spring 2019)

Lab – IV Epileptic seizures

Objective

The aim of this exercise is to learn to analyze the changes in EEG to detect or predict epileptic seizures. The data provided is a sample of EEG data recorded from a single frontal channel.
During this segment of 17 minutes there are three seizures taking place.
In this exercise, you will first present the raw EEG from the whole sample of 17 minutes, where visually someone can distinguish the occurrences of the three epileptic seizures. Next, you will calculate the spectrogram of the signal. Using this information, you will also present the spectral entropy for the EEG signal. Again visually, someone can detect the epileptic seizures denoted by the sudden drop in entropy.
Furthermore, you will present a small EEG segment during an ictal state and compare it with another segment from an interictal state.
Last, you will give a larger segment that includes, the preictal, ictal, and postictal state so that to apply nonlinear methods for time series analysis. Specifically the 2D embedding procedure will be used.

In order to pass the exercise, all correctly executed task results marked with an arrow bullet (➢) must be personally presented to a course assistant during the scheduled laboratory exercise.

Implementation

The data and instructions needed for this exercise can be found in the Biosignal Processing II course webpage (see the Noppa system link in the footer of this document).

Download the data file ‘521282S_eeg_data_4’ containing the EEG data vector variable ‘signal’, time vectors ‘t’, (time in minutes), ‘t1’, ‘t2’ (time in seconds), and sampling frequency ‘Fs’. Recall the usage of the spectrogram and the calculation of the spectral entropy from a previous exercise.

Store your solutions in **a single script code m-file** that provides the required task results.

1. Linear time series analysis

Load the data file ‘521282S_eeg_data_4’…

Display the RAW EEG signal.

Calculate the spectrogram of the signal using the function ‘spectrogram’. For input, use the raw EEG data, 30s window, 29s overlap, and sampling frequency ‘Fs’. In addition, define the frequencies at which the spectrogram is computed (input parameter ‘F’ given before the sampling frequency ‘Fs’) by vector [0.1:0.1:32] to get the estimates between frequencies 0.1Hz and 32Hz with 0.1Hz resolution. Collect all of the four output parameters (‘S’, ‘F’, ‘T’, and ‘P’) of the function.

You can use the code from the previous exercise to calculate the spectral entropy

- Plot the RAW EEG signal utilizing the time vector ‘t’. Utilize the function ‘subplot’ with three rows and one column to fit the results from the next tasks as well. Scale the y axis using the [-1000 1000] limits.
- Plot in the same figure the spectrogram as in the previous exercise setting [-4 6] as the limits. Use also the command ‘axis xy’ to reflect the image vertically.
- Next, plot the spectral entropy in the same figure.

View and compare the two 10 second EEG segments, one from an ictal state, and another one from an interictal state.

- Store the EEG segments in the ‘signal1’ and ‘signal2’ vectors. Then plot the raw EEG signal segments in the same figure using subplot and time vector ‘t1’ for both cases. Scale the axes similar to the previous task.

2. Nonlinear methods

Acquire and display a larger segment that contains the first ictal event from the given EEG sample including both the preictal and postictal periods as well as some normal interictal period before and after the ictal state. From the original RAW EEG signal you can use the segment from 208 sec. to 440 sec.

Note that in this segment the ictal period should start after the 100 sec. point and it should have duration of 32 seconds. You may consider as pre and post ictal periods 10 seconds before and after the ictal period.

Next, perform 2D embedding for the analysis of the time series. Here, two points of the time series are plotted as one single point in a two-dimensional state space diagram.

$$X_i = [X_{i,} X_{i+\Delta}]$$

To demonstrate the transition from normal to ictal, represent with cyan marks the seizure state, with black marks the routes to seizure onset by including the pre and post ictal state and with red marks the inter-ictal attractor.

Fair results can be obtained by using delta equal to 67.

The material used in this exercise can be found in the course web page at
https://noppa.oulu.fi/noppa/kurssi/521282s/harjoitukset

- Plot the RAW EEG segment using the time vector ‘t2’ and once again scale the axes similar to the other tasks.
- Plot in the 2D space using blue red and black markers as described. To do that create the two 2D space using ‘plot([-1500 1500],[-1500 1500], '.')’ and add dot marks using the plot function.

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